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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

REINFORCED COMPONENT

Inventors: Kevin T. Burt
John P. Frechette

Assignee: Crane Plastics Company LLC

Attorneys: Standley Law Group LLP
Attn.: Jeffrey S. Standley
495 Metro Place South
Suite 210
Dublin, Ohio 43017-5319
Telephone: (614) 792-5555
Fax: (614) 792-5536
E-mail: jstandley@standleyllp.com

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Inventors: Kevin T. Burt

John P. Frechette

[0001] This is a continuation-in-part of U.S. Application No. 10/452,612, filed June 2, 2003, which claims the benefit of U.S. Provisional Application No. 60/450,415, filed February 27, 2003, each of which is hereby incorporated by reference in its entirety.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] The present invention relates generally to components made from composite materials. Examples of composite materials include plastic composites that include cellulosic fillers and/or inorganic fillers. Cellulosic-filled plastic composites may also be known as synthetic wood composites or, more simply, wood composites.

[0003] Plastics composites may be used as a substitute for natural woods. The supply of natural woods for construction and other purposes is dwindling. When a tree is harvested for manufacturing purposes, it takes many years to grow another tree of similar size in its place. As a result, many are concerned about conserving the world's forests, and the cost of natural woods has risen. In light of these factors, a tremendous demand has developed in recent years for wood composites that exhibit the look and feel of natural woods.

[0004] Wood fiber/polymer composites and wood flour/polymer composites have been used as replacements for all-natural wood, particle board, wafer board, and other similar materials. For example, U.S. Patent Nos. 3,908,902; 4,091,153; 4,686,251;

4,708,623; 5,002,713; 5,055,247; 5,087,400; and 5,151,238 relate to processes for making wood replacement products. Wood composites may provide desired appearance, strength, durability, weatherability, and other structural characteristics. As compared to natural woods, wood fiber/polymer composites and wood flour/polymer composites may offer superior resistance to wear and tear. In addition, wood fiber/polymer composites and wood flour/polymer composites may have enhanced resistance to moisture. In fact, it is well known that the retention of moisture is a primary cause of the warping, splintering, and discoloration of natural woods. Moreover, wood fiber/polymer composites and wood flour/polymer composites may be sawed, sanded, shaped, turned, fastened, and finished in a similar manner as natural woods. Consequently, wood fiber/polymer composites and wood flour/polymer composites have been used for applications such as interior and exterior decorative house moldings, picture frames, furniture, porch decks, deck railings, window moldings, window components, door components, roofing structures, building siding, and other suitable indoor and outdoor items.

[0005] Like natural wood, plastic composites are subject to stress caused by load conditions or the conditions of the environment. For instance, plastic composites can expand, contract, bend, warp, creep, or undergo other structural changes over time in response to environmental or load conditions. In addition, fasteners may withdraw from plastic composites in a manner similar to which fasters back out of natural wood. Accordingly, there is a need for further improving the structural characteristics of plastic composites.

[0006] The present invention is directed to a component in which a substrate is embedded in a plastic composite. Any of a variety of substrates and plastic composites may be used to achieve the desired component characteristics. One example of a component of the present invention is comprised of a substrate sheet that is embedded in a plastic composite. Another example of a component of the present invention is a perforated substrate that is embedded in a plastic composite.

[0007] In addition to the novel features and advantages mentioned above, other features and advantages of the present invention will be readily apparent from the following descriptions of the drawings and exemplary embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is a partial side elevation view of an exemplary embodiment of a component of the present invention. In this figure, the substrate is exposed for illustrative purposes.

[0009] Figure 2 is an end elevation view of the component of Figure 1.

[0010] Figure 3 is a partial perspective view of an exemplary embodiment of an assembly that may benefit from the present invention. In this figure, the substrate is exposed for illustrative purposes.

[0011] Figure 4 is a diagram of an exemplary embodiment of an extruder and cross-head die system.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENT(S)

[0012] The present invention is directed to a component in which a substrate is embedded in a plastic composite. The inventors have discovered that deck rails and fence rails, in particular, benefit from the present invention. For the same reasons,

other components may also benefit from the present invention. For instance, the present invention may be used to make components that have previously been made from plastics, plastic composites, other composites, metals, wood, and other structural or building materials. Examples of components include interior and exterior decorative house moldings, picture frames, furniture components, porch decks, deck components, deck joists, dock components, panels, planks, window components, window moldings, window lineals, door components, roof components, wall components, fence components, fence posts, floor components, building siding, siding accessories, and other suitable indoor and outdoor items. In addition, a variety of other components may also be made using the present invention.

[0013] Figures **1** and **2** show an exemplary embodiment of a component of the present invention. Component **10** is comprised of a plastic composite **12** and a substrate **14**. At least a portion of the substrate **14** is embedded in the plastic composite **12**. The plastic composite **12** may cover some or all sides of the substrate **14**. Figure **2** shows a preferred embodiment in which the substrate **14** is covered on all sides by the plastic composite **12**. The substrate **14** may be embedded in the plastic composite **12** by any suitable means. For example, the plastic composite **12** may be formed on the substrate **14** such that the substrate **14** becomes embedded in the plastic composite **12**. The plastic composite **12** may be formed on the substrate **14** by extrusion, compression molding, injection molding, or any other similar or suitable hot melt process.

[0014] The substrate **14** may have any suitable shape and dimensions to provide the desired component characteristics. In this example, the substrate **14** is a sheet. As

shown in Figure **1**, the sheet may have at least one perforation **16**. In this type of embodiment, the plastic composite **12** may flow through the aperture(s) **16**, thereby locking the substrate **14** in the plastic composite **12**. An aperture **16** may have any suitable shape and dimensions. Preferably, an aperture is sufficiently large to allow the passage of the plastic composite **12**. In one exemplary embodiment, an aperture **16** is a circle having a diameter of about 0.0625 in. However, it is not intended to limit the aperture to any particular shape or dimensions. Similarly, the spacing between the apertures may be selected to provide the desired component characteristics.

[0015] The substrate may be solid in other embodiments. In such an embodiment, the plastic composite may formed at least partially around the substrate such that it becomes embedded. An adhesive or any other suitable tie layer may be used to facilitate embedding the substrate in the plastic composite.

[0016] The substrate may be made from any material that is suitable for providing the desired component characteristics. In one exemplary embodiment, the substrate may be made from any material that has more bending strength or rigidity than the plastic composite. In other words, a piece of the material used for the substrate may have a higher bending strength or rigidity than a comparable size piece of the plastic composite. In another exemplary embodiment, the substrate may be selected for improving the fastener retention of the component. Metal and metal alloys are examples of materials that are suitable for use as a substrate in the present invention. Examples of metal include steel, aluminum, and other similar or suitable metals and metal alloys. Fiberglass is another example of a material that may be used as a substrate in the present invention. Still other examples of materials that may be

used as a substrate include, but are not limited to, wood, pre-formed wood composites, pre-formed plastic composites (such as, but not limited to, inorganic-filled plastic composites and cellulosic-filled plastic composites), pre-formed plastics, glass, concrete, other types building or construction materials, other similar or suitable materials that have a higher bending strength or rigidity than the plastic composite, and other similar or suitable materials that improve the fastener retention of the resulting component.

[0017] Figure **3** shows an example of a fence or railing assembly that may implement the present invention. The assembly **20** includes a post **22**, plank **24**, and rail **26**. Any of these components may be made according to the present invention. In this example, the rail **26** includes a perforated steel sheet **28**. For exemplary purposes only, the rail **26** is 3 inches by 1 inch, and the perforated sheet **28** is 0.030 inch by 2.5 inches. Fasteners **30** and **32** extend through plank **24** and into rail **26** to preferably engage substrate **28**. The size and position of the fasteners **30** and **32** as well as the size and position of the apertures in the substrate **28** may be selected such that the fasteners **30** and **32** extend though the metal. If the fasteners **30** and **32** engage the substrate **28**, this may increase the retention of fasteners **30** and **32**. In addition, the perforated substrate **28** may help to limit creep by the rail **26**.

[0018] Any desired plastic composite may be used in the present invention. The present invention may be particularly useful for products made from cellulosic-filled and/or inorganic-filled plastic composites. Nevertheless, it should be recognized that the product may be made from other types of plastic composites without departing from

the scope of the present invention. Examples of plastic composites include, but are not limited to, polyolefin composites and polyvinyl chloride composites.

[0019] A cellulosic-filled plastic composite may be comprised of materials that include, but are not limited to, cellulosic fillers, polymers, inorganic fillers, cross-linking agents, lubricants, process aids, stabilizers, accelerators, inhibitors, enhancers, compatibilizers, blowing agents, foaming agents, thermosetting materials, pigments, anti-oxidants, and other suitable materials. Examples of cellulosic fillers include sawdust, newspapers, alfalfa, wheat pulp, wood chips, wood fibers, wood particles, ground wood, wood flour, wood flakes, wood veneers, wood laminates, paper, cardboard, straw, cotton, rice hulls, coconut shells, peanut shells, bagass, plant fibers, bamboo fiber, palm fiber, kenaf, and other similar materials. Examples of polymers include multilayer films, high density polyethylene (HDPE), low density polyethylene (LDPE), chlorinated polyethylene (CPE), polypropylene (PP), polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), acrylonitrile butadiene styrene (ABS), ethyl-vinyl acetate (EVA), other similar copolymers, other similar, suitable, or conventional thermoplastic materials, and formulations that incorporate any of the aforementioned polymers. Examples of inorganic fillers include talc, calcium carbonate, kaolin clay, magnesium oxide, titanium dioxide, silica, mica, barium sulfate, and other similar, suitable, or conventional materials. Examples of cross-linking agents include polyurethanes, such as isocyanates, phenolic resins, unsaturated polyesters, epoxy resins, and other similar, suitable, or conventional materials. Combinations of the aforementioned materials are also examples of cross-linking agents. Examples of lubricants include zinc stearate, calcium stearate, esters, amide wax, paraffin wax,

ethylene bis-stearamide, and other similar, suitable, or conventional materials. Examples of stabilizers include light stabilizers, tin stabilizers, lead and metal soaps such as barium, cadmium, and zinc, and other similar, suitable, or conventional materials. In addition, examples of process aids include acrylic modifiers and other similar, suitable, or conventional materials. Examples of pigments include titanium dioxide and other similar or suitable white additives.

[0020] One example of a polyolefin composite is a cellulosic/HDPE material. The composite material may be comprised of at least one cellulosic filler in an amount of about 40% to about 70% by weight, more preferably about 50% to about 60%. Additionally, the composite material may be comprised of HDPE material in an amount of about 30% to about 60% by weight, more preferably about 40% to about 50% by weight. The HDPE material is comprised of HDPE. The HDPE may be of any desired type, and it may have any desired melt index (MI). The HDPE may be incorporated in any desired form, but powder reactor flake form is preferred to facilitate mixing with the cellulosic filler. Optionally, the HDPE material may include other ingredients in addition to the HDPE. For instance, process aids may be included in the amount of 0% to about 10% by weight of the composite, more preferably about 1% to about 5% by weight of the composite. Examples of such other process aids include lubricants, e.g., wax and zinc stearate, and other types of stabilizers, e.g., metal soaps. Furthermore, the HDPE material may include at least inorganic filler, e.g., talc and other mineral fillers, in the amount of about 0% to about 20% by weight of the composite, more preferably about 5% to about 15% by weight of the composite.

[0021] On the other hand, an example of a polyvinyl chloride composite may include at least one cellulosic filler in the amount of about 30% to about 60% by weight, more preferably about 40% to about 50% by weight, and still more preferably about 45% to about 50% by weight. The composite may also include a PVC material in the amount of about 40% to about 70% by weight, more preferably about 50% to about 60% by weight, and still more preferably about 50% to about 55% by weight. The PVC material may include stabilizer(s) in an amount of about 1 to about 10 parts, more preferably about 3 to about 5 parts, per 100 parts of the PVC resin. The lubricant(s) may be present in an amount of about 2 to about 12 parts, more preferably about 4 to about 8 parts, per 100 parts of the PVC resin. Also, process aid(s) may be included in an amount of about 0.5 to about 8 parts, more preferably about 1 to about 3 parts, per 100 parts of the PVC resin. Optionally, at least one inorganic filler may be added in an amount of up to about 10 parts, more preferably up to about 5 parts, per 100 parts of the PVC resin.

[0022] As previously mentioned, an example of a cellulosic filler is wood flour. In an exemplary embodiment of the present invention, the wood flour may have a mesh size between about 40 and about 60. The wood flour may be selected from any desired type of wood including, but not limited to, oak, maple, and pine.

[0023] In an exemplary method of making a product of the present invention from a cellulosic composite, the cellulosic filler(s) may be dried to a desired moisture content. For example, the cellulosic filler(s) may be dried to about 0.5% to about 3% moisture content by weight, more preferably to about 1% to about 2% moisture content by weight. However, it is appreciated that the cellulosic filler(s) may have a moisture

content less than about 0.5% by weight or greater than about 3% by weight. In addition, it should be recognized that an in-line compounding and extrusion system may be utilized to eliminate a pre-drying step.

[0024] Some or all of the composite ingredients may be combined in a mixer prior to introduction into a molding apparatus such as an extruder (which may include a die system), a compression molding apparatus, an injection molding apparatus, or any other similar or suitable molding apparatus. Also, some or all of the ingredients may be separately introduced into the molding apparatus. One example of a mixer is a high intensity mixer such as those made by Littleford Day Inc. or Henschel Mixers America Inc. Another type of a mixer is a low intensity mixer including, but not limited to, a ribbon blender. The type of mixer may be selected to blend the ingredients at desired temperatures. An example of an extruder is a conical, twin screw, counter-rotating extruder with a vent. At least one force feed hopper, crammer, or any other suitable, similar, or conventional apparatus may be used to feed the materials into the extruder. Using a cross-head die, the resulting plastic composite may be formed on the substrate.

[0025] Figure **4** shows an example of an in-line manufacturing system **40** that may be used to make a component of the present invention. In this exemplary embodiment, a metal sheet **42** is provided to an extrusion system that processes the plastic composite. The extrusion system may be comprised of at least one extruder, at least one die, and other suitable extrusion equipment. Figure **4** shows an extruder **44** and a cross-head die **46** of the exemplary extrusion system. As the metal sheet **42** passes through the die **46**, the extruded plastic covers the metal sheet **42**. The plastic

may coat some or all portions or sides of the metal sheet **42**. It should be understood that a tie layer may be provided between the metal sheet and the plastic. Examples of a tie layer include adhesives, epoxies, resins, polymers, and other similar, suitable, or conventional materials that promote the bonding of plastics and metals. The tie layer may be heat activated if desired. One exemplary embodiment of an adhesive is an acrylic/phenolic adhesive that is available from SIA Adhesives. A tie layer may be applied on the metal sheet before it is provided to the extrusion system, or a tie layer may be coated on the metal sheet in the extrusion system. In such instances, it should be understood that the plastic still coats the metal sheet. One exemplary embodiment in which a tie layer may be useful is a component that comprises a solid metal sheet that is embedded in a PVC composite.

[0026] The die system **46** may include a fold-up die, a calibrator, a sizer, or any other similar or suitable equipment for making extruded products. The resulting product **48** may undergo roll forming, cold forming, hydro forming, and other similar or suitable manufacturing techniques. Also, after exiting the die system, the extruded product may be cooled. For example, the extruded product may be cooled by submersing it in a water bath, passing it through a cooling liquid spray, and/or drying it with compressed gas or cryogenic fluid.

EXAMPLE

[0027] An example of a rail component of the present invention was made and compared to a similar rail without an inner substrate layer. The component of the present invention was also compared to a pine board. The testing consisted of withdrawing a #8 galvanized deck screw which had been inserted to a depth of 1.25

inches in each type of component to compare fastener retention. The testing demonstrated the component of the present invention exhibited significantly improved fastener retention. The test results are shown below.

COMPONENT	(LBS/INCH OF DEPTH)
Rail With Perforated Steel	1065
Rail Without Perforated Steel	867
CCA Treated S.Y. Pine Board	568

[0028] Any embodiment of the present invention may include any of the optional or preferred features of the other embodiments of the present invention. The exemplary embodiments herein disclosed are not intended to be exhaustive or to unnecessarily limit the scope of the invention. The exemplary embodiments were chosen and described in order to explain the principles of the present invention so that others skilled in the art may practice the invention. Having shown and described exemplary embodiments of the present invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention. Many of those variations and modifications will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.